

CLAIMS

What is claimed is:

1. A method for depositing a deposition material on a part comprising:
placing the part in a deposition chamber;
applying a first electric potential to the part;
evaporating one or more first components for forming the deposition material;
ionizing the evaporated first components, the first electric potential drawing the ionized first components toward the part; and
sputtering one or more second components for forming the deposition material, the sputtered second components being codeposited with the ionized first components.
2. The method of claim 1 wherein:
the sputtering comprises applying a sputtering voltage to a sputtering target.
3. The method of claim 2 wherein:
the sputtering target encircles an ion flowpath from a source of the first components to the part.
4. The method of claim 1 wherein:
the one or more second components comprise one or more refractory elements.
5. The method of claim 1 wherein:
the one or more second components consist essentially of Mo.
6. The method of claim 1 wherein:
the deposition material consists essentially of at least one of Ti-6Al-2Sn-4Zr-2Mo, Ti-8Al-1V-1Mo, or Ti-6Al-2Sn-4Zr-6Mo.
7. The method of claim 1 wherein:
the part has lost first material from a site; and
the deposition material is deposited to the site so as to restore the part.
8. The method of claim 7 wherein:
the deposition material has a first interface with a substrate of the part, a bond strength

between the deposition material and the substrate being in excess of 50ksi.

9. The method of claim 8 wherein:

the part and the deposition material comprise Ti alloys or nickel- or cobalt-based superalloys of like nominal composition;

the bond strength is between 100ksi and 200ksi;

the deposition material has a depth of at least 2.0mm;

the substrate has a thickness in excess of the depth of the deposition material; and

the substrate comprises original unrepaired material.

10. The method of claim 1 wherein:

the part is a Ti alloy turbine engine part and the deposition material is Ti-based.

11. An apparatus for depositing material on a workpiece comprising:

a deposition chamber;

means for forming a plasma from one or more first deposition material components;

means for applying a modulated bias electric potential to the workpiece to draw ions from the plasma to the workpiece;

means for sputtering one or more second deposition material components; and

a control system coupled to the means for forming, means for applying, and means for sputtering and programmed so as to provide feedback loop control of codeposition of the first and second deposition material components to the workpiece.

12. The apparatus of claim 11 further comprising:

means for monitoring a density of the plasma and an ion current to the workpiece.

13. The apparatus of claim 11 wherein:

the means for sputtering comprises:

a first sputtering target providing a first of said one or more second deposition material components; and

a second sputtering target providing a second of said one or more second deposition material components; and

the control system is programmed to independently control first and second sputtering bias voltages applied to the first and second sputtering targets.

14. An apparatus for depositing deposition material on a workpiece comprising:
 - a deposition chamber;
 - a workpiece in the deposition chamber and subject to a first non-zero bias voltage;
 - a first source of one or more first components of the deposition material heated so as to vaporize the first components; and
 - a first sputtering target in the deposition chamber comprising one or more second components of the deposition material and subject to a second bias voltage.
15. The apparatus of claim 14 wherein:
 - the one or more first components include Ti, Al, and V; and
 - the one or more second components consist essentially of Mo.
16. The apparatus of claim 14 wherein:
 - first bias voltage is different from the second bias voltage.
17. The apparatus of claim 14 wherein:
 - first and second bias voltages are pulse modulated voltages differing in at least one of magnitude and duty cycle.
18. The apparatus of claim 14 further comprising:
 - a second sputtering target, differing in composition from the first sputtering target, and subject to a third non-zero bias voltage, different from the second bias voltage.
19. A method for codepositing a deposition material of one or more first components and one or more second components depositing comprising:
 - ion-enhanced electron beam physical vapor deposition of the one or more first components; and
 - sputtering of the one or more second components.
20. The method of claim 19 wherein:
 - the one or more first components are from a single ingot; and
 - the one or more second components are at least two components from at least two different sputtering targets of different composition.